The present invention relates to an improved method for the working of metals. In its preferred aspect, this invention relates to an improved method for the drawing and shaving of copper and aluminum involving the use of a lubricant comprised of a particular class of diamine salts of fatty acids.

Metal working operations such as drawing, milling, cutting, and the like, involve the common principle of contacting the surface of a metal part with a shaping tool or element so as to change the conformation or surface characteristics of the metal part. When such operations are carried out without the aid of lubricants, an undesirable amount of heat friction is generated at the points of contact and a welding or binding effect is noted. Unless this heat is dissipated, damage results to both the tool and the metal part, and in the case of poorly lubricated deep-drawing operations there is the additional danger of fracturing the metal part. Chattering is another effect of poor lubrication in drawing operations and often results in the rejection of the finished product due to rough or irregular surfaces.

For obvious economic reasons, low cost lubricants are the most desirable in metal working operations. It is well known, however, that non-surface active lubricants such as mineral oils and vegetable oils are unsatisfactory for many working operations, especially the drawing of metals. Such lubricants have a tendency to flow away from the precise area in which the heat and pressure are greatest, and where lubrication is most effective in preventing binding.

Emulsions of soap and fat in water have been used as cutting and drawing compounds. The degree of success attained with these compounds is due to the fact that soap, being surface active, adheres to the surface of the metal being processed as well as to the surface of the shaping tool. Likewise, soap has an affinity for fat which is thus held upon the surface of the metal in a lubricative film. However, fat and soap are unavoidably caustic in nature and as a result of their use the metallic surface becomes corroded.

In general, a surface active compound is composed of a combination of a water-soluble or hydrophilic chemical group and an oil-soluble or hydrophobic chemical. If such a compound does not ionize, it is said to be nonionic, while if it does ionize, it is said to be ionic. When that part of the ionized molecule containing an oil-soluble portion is the positive ion, the compound is said to be cation-active or cationic. Those ionic compounds such as soap having the oil-soluble group as the anion, are known as anionic agents.

In accordance with the present invention, I have discovered that a metal working operation can be vastly improved, especially the shaving and drawing of copper and aluminum, by the elimination of chattering, increased life, improved surfaces and the prevention of corrosion, if the process is carried out in the presence of a lubricant composition comprised of a conventional mineral lubricating oil having incorporated therein between about 5 and 25 weight percent of a mono- or di-fatty acid salt of a particular class of diamine compounds. These diamines can be represented by the general formula $\text{RNHC}_2\text{CH}_2\text{CH}_2\text{NH}_2$ wherein R is an aliphatic hydrocarbon radical having from 8 to 22 carbon atoms. Examples of these aliphatic hydrocarbon radicals include the octyl, nonyl, decyl, undecyl, dodecyl, tri-decyl, tetradecyl, pentadecyl, hexadecyl, heptadecyl, octa-decyl, octadecyl, octadecadienyl, octadecatrienyl, eicosyl, and docosyl radicals, and mixtures of the foregoing aliphatic hydrocarbon radicals as are contained in the statistical mixtures present in vegetable and animal oils such as tallow, soybean oil, cottonseed oil, coconut oil, and the like. A preferred diamine is N-tallow-trimethylenediamine. These diamine compounds are well known commercial chemicals and are sold under the trade name Duomeen.

The fatty acids which are combined with the above defined diamines to form the mono- and di-acid salts useful in the present invention are those fatty acids having from 8 to 22 carbon atoms, as for example, caprylic acid, capric acid, lauric acid, myristic acid, palmitic acid, linolenic acid, and also the well-known mixtures of the foregoing acids which are derived by the hydrolysis of vegetable and animal oils such as tallow, soybean oil, cottonseed oil, and the like. Also, the unsaturated fatty acids present in tallow oil can also be used. A preferred acid is oleic acid having 18 carbon atoms in the molecule. A preferred lubricant composition of the present invention is a solution of from 5 to 25 weight percent of N-tallow-trimethylenediamine diolcete in mineral oil.

In use, the diamine-fatty acid salts are strongly adsorbed onto the metallic surfaces. Because of their cationic nature, they preferentially wet the metal surfaces giving a highly uniform and tenacious mono-molecular layer which improves the lubricating action of the main body of lubricant. The oil-wettable film also provides a water-impervious barrier which prevents corrosion of the metallic surfaces.

In a cutting or drawing operation, the surface of the metal to be formed can be immersed in the lubricant composition before passing to the forming elements such as drawing dies or cutting tools. If the metal stock cannot be conveniently immersed in the bath, the lubricant containing the diamine-fatty acid salt can be sprayed or poured onto the metal surface before it is subjected to the forming step. Depending upon the conditions encountered, the lubricant can be applied to the metal surfaces in the form of a paste or grease, as for example, petroleum containing from 5 to 25 weight percent of the diamine-fatty acid salts, or as a solution of the diamine-fatty acid salt in mineral oil. The method of applying the lubricant is not limited to immersion of the metal part, or spraying or pouring. In general, any method of application is suitable which results in contacting the lubricant at the interface between the metal surface and the metal-working tool. Before passing to the metal-working step, the wetted metal surface can if desired first be allowed to dry without appreciably impairing the lubricative qualities. After the metal stock has been coated with a film of the diamine-fatty acid salt-containing lubricant, it can be processed with at least one forming tool before it is necessary to re-treat the surface with more lubricant. In some cases as many as three successive forming operations can be carried out without intermediate lubrication.

The present invention is preferably directed to the drawing and shaving of copper and aluminum. It should not, however, be considered as being limited to these operations and metals since it can be practiced in any operation involving lubrication of the interface between a metal surface and a metal-working tool.
The present invention can be better understood by reference to the following examples:

**Example I**

A solution containing 10 percent by weight of N-tallow-trimethylene diamine dioleate in 300 second paraffin oil was employed as a lubricant in the bench drawing of soft copper tubing at reductions of 32 to 38 percent. This lubricant combination resulted in a die life increase of 80 to 100 percent, a reduction of breakers, cooler and cleaner operations, and the elimination of chattering as opposed to the use of the mineral oil not containing the N-tallow-trimethylene diamine dioleate.

In plant operation there is an occasional fluctuation of temperature in the annealing furnace causing some tubing to be under annealed while others are heated to a point where an oxide coating occurs on the interior of the tube. Breaking usually occurs on further drawing operations. This breaking can be substantially reduced by increasing the concentration of the N-tallow-trimethylene diamine dioleate in the oil.

**Example II**

A 20 percent concentration of N-tallow-trimethylene diamine dioleate in petrolatum was tested as a replacement for straight petrolatum in drawing aluminum tubing. The petrolatum with the N-tallow-trimethylene diamine dioleate added produced a smoother draw with lower power requirements and the elimination of chattering.

**Example III**

A 20 percent concentration of N-tallow-trimethylene diamine dioleate in 100 second paraffin oil was substituted for tallow in a fine copper wire drawing operation. The substitution resulted in a die life increase of 150 to 190 percent along with a smoother finish and cleaner operating conditions.

**Example IV**

A paste formulation was prepared containing 19.5 parts by weight of N-tallow-trimethylene diamine dioleate, 19.5 parts of tallow amine acetate, 25 parts of soya-N-bis(2-hydroxyethyl) amine phosphate, 23 parts of water and 13 parts of hexylene glycol. This paste formulation was used in die boxes for rod shaving where lubricity, lubricant pick-up and lubricant flow characteristics are important. A 9/16" copper rod was drawn through the paste, shaved and then through an oil dilution of the paste. The rod was fed to the bottom of a capstan and, after three winds, was taken off the top and reeled. The paste lubricant imparted excellent slip characteristics to the rod so that no guide was needed to prevent overwinds and kinking. When used on intermediate drawings in the box prior to entry into the machine, the paste containing the N-tallow-trimethylene diamine dioleate gave excellent results and the die life was increased by 40 percent. On fine wire drawing, the paste formulation increased the life expectancy of the initial carbide die from 24 to 144 hours.

While this invention has been described and exemplified in terms of its preferred modifications, those skilled in the art will appreciate that variations can be made without departing from the spirit and scope of the invention. For example, other formulated lubricating compositions can be prepared having incorporated therein the diamine-fatty acid salts hereinbefore defined in concentrations ranging between 5 and 25 percent by weight. At such a concentration level the diamine-fatty acid salt is strongly adsorbed onto metallic surfaces, preferentially wetting the surfaces and giving a highly uniform and tenacious mono-molecular layer which improves the lubricating action of the main body of lubricant.

I claim:

1. A method of treating metal which comprises deforming with a metal working tool metal in contact with a major amount of a metal working lubricant selected from the group consisting of petrolatum and mineral oils containing from 5 to 25% by weight of a fatty acid having from 8 to 20 carbon atoms and a diamine having the formula RNHCH₂CH₂NH₂ wherein R is an aliphatic hydrocarbon radical having from 8 to 22 carbon atoms.

2. A method of treating metal which comprises deforming with a die metal in contact with a major amount of a metal working lubricant selected from the group consisting of petrolatum and mineral oils containing from 5 to 25 weight percent of a salt of a fatty acid having from 8 to 22 carbon atoms and a diamine having the formula RNHCH₂CH₂NH₂ wherein R is an aliphatic hydrocarbon radical having from 8 to 22 carbon atoms.

3. A method of treating copper and aluminum which comprises deforming with a metal working tool the copper and aluminum while the latter are in contact with a major amount of a metal working lubricant selected from the group consisting of petrolatum and mineral oils containing from 5 to 25 weight percent of the oleic acid salt of a diamine having the formula RNHCH₂CH₂NH₂ wherein R is an aliphatic hydrocarbon radical having from 8 to 22 carbon atoms.

4. A method for drawing metal which comprises extruding through a die metal in contact with a major amount of a metal working lubricant selected from the group consisting of petrolatum and mineral oils containing from 5 to 25 weight percent of N-tallow-trimethylene diamine dioleate.

5. A method of drawing copper metal which comprises extruding through a die aluminum metal in contact with a major amount of a metal working lubricant selected from the group consisting of petrolatum and mineral oils containing from 5 to 25 weight percent of N-tallow-trimethylene diamine dioleate.

6. A method of drawing aluminum metal which comprises extruding through a die aluminum metal in contact with a major amount of a metal working lubricant selected from the group consisting of petrolatum and mineral oils containing from 5 to 25 weight percent of N-tallow-trimethylene diamine dioleate.

7. A method according to claim 5 wherein the lubricant contains 10% by weight of N-tallow-trimethylene diamine dioleate.

8. A method according to claim 6 wherein the lubricant contains 20% by weight of N-tallow-trimethylene diamine dioleate.

9. A method of treating metal which comprises deforming with a metal working tool metal in contact with a paste formulation consisting of about 19.5 parts by weight of N-tallow trimethylene diamine dioleate, about 19.5 parts by weight of tallow amine acetate, about 25 parts by weight of soya-N-bis(2-hydroxyethyl) amine phosphate, about 23 parts by weight of water and about 13 parts by weight of hexylene glycol.

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